



The Finnish Geodetic Institute



# Virtual DGPS Based on SBAS Signal

*Ruizhi Chen*

*Finnish Geodetic Institute*

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# Background



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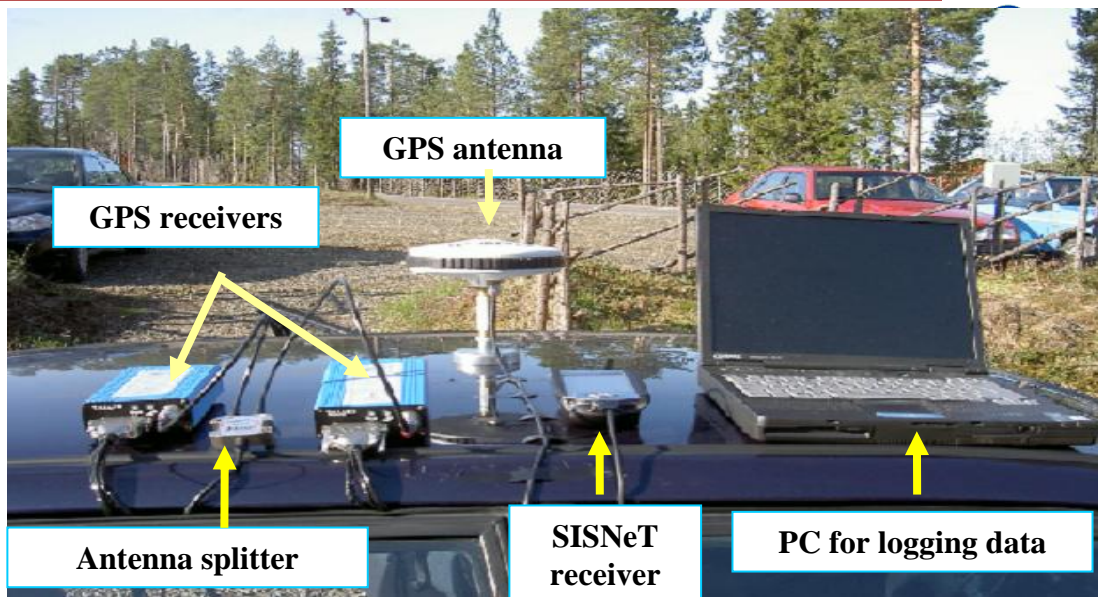
- The low elevation angles to the GEO satellites at high latitudes (ranging from 4-22 degrees from Finland to the EGNOS GEO satellites), make it difficult to access the SBAS services for land applications.
- EGNOS GEO satellites are not visible in city canyons even in central Europe.
- It takes very long to initiate the SBAS positioning process when the availability of the SBAS SIS is low.
- Access to the SBAS service via the old DGPS receivers



# EGNOS Positioning Accuracy and SIS Availability in Finland

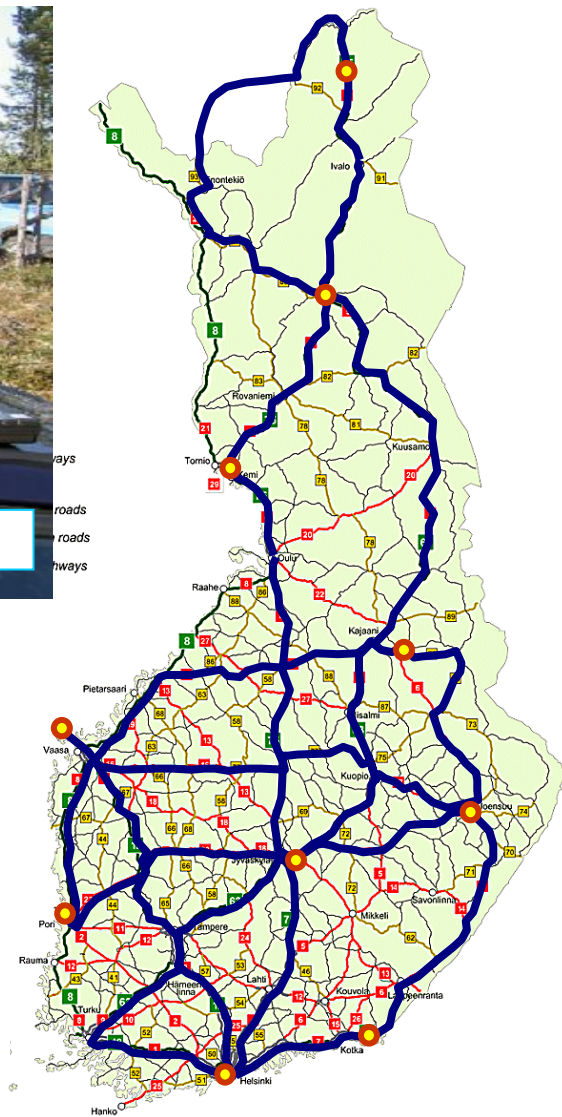


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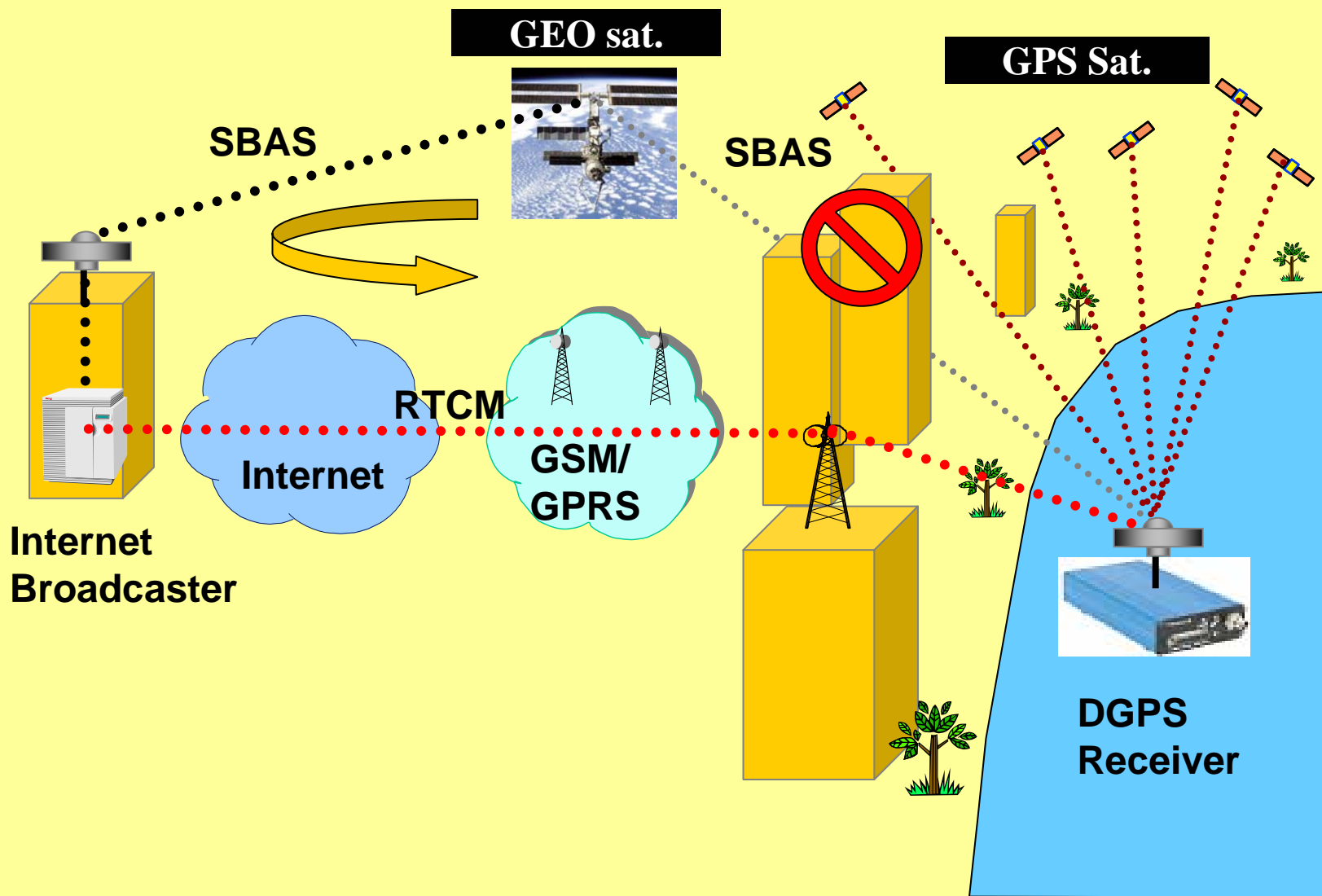
Levels	North	East	Height
67%	0.69 m	0.90 m	1.81 m
95%	1.70 m	1.90 m	4.64 m

**ONLY 51% of the 6100 km driving routes can access the EGNOS GEO satellites.**





# Virtual DGPS-Concept

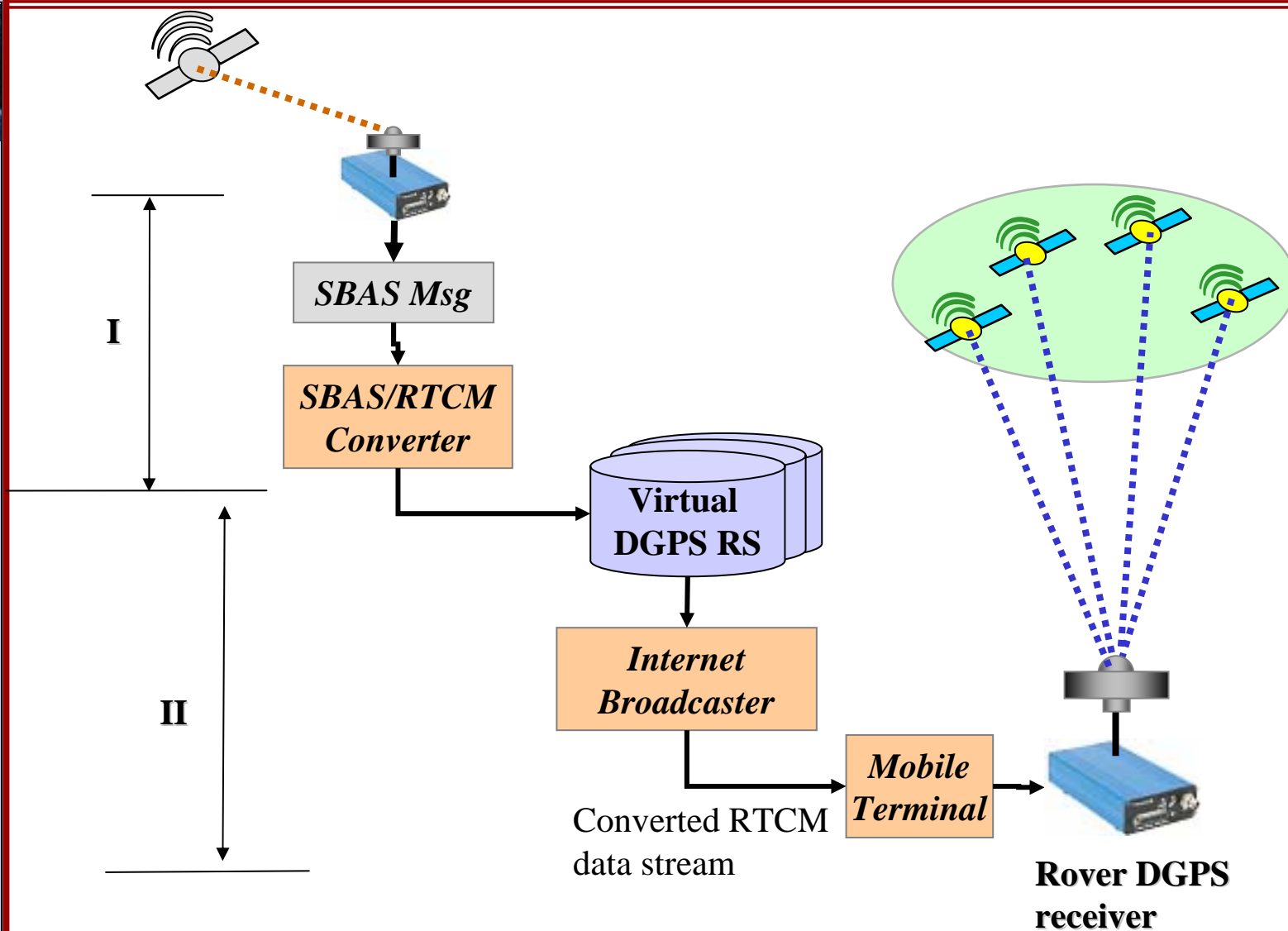




# Virtual DGPS - Infrastructure



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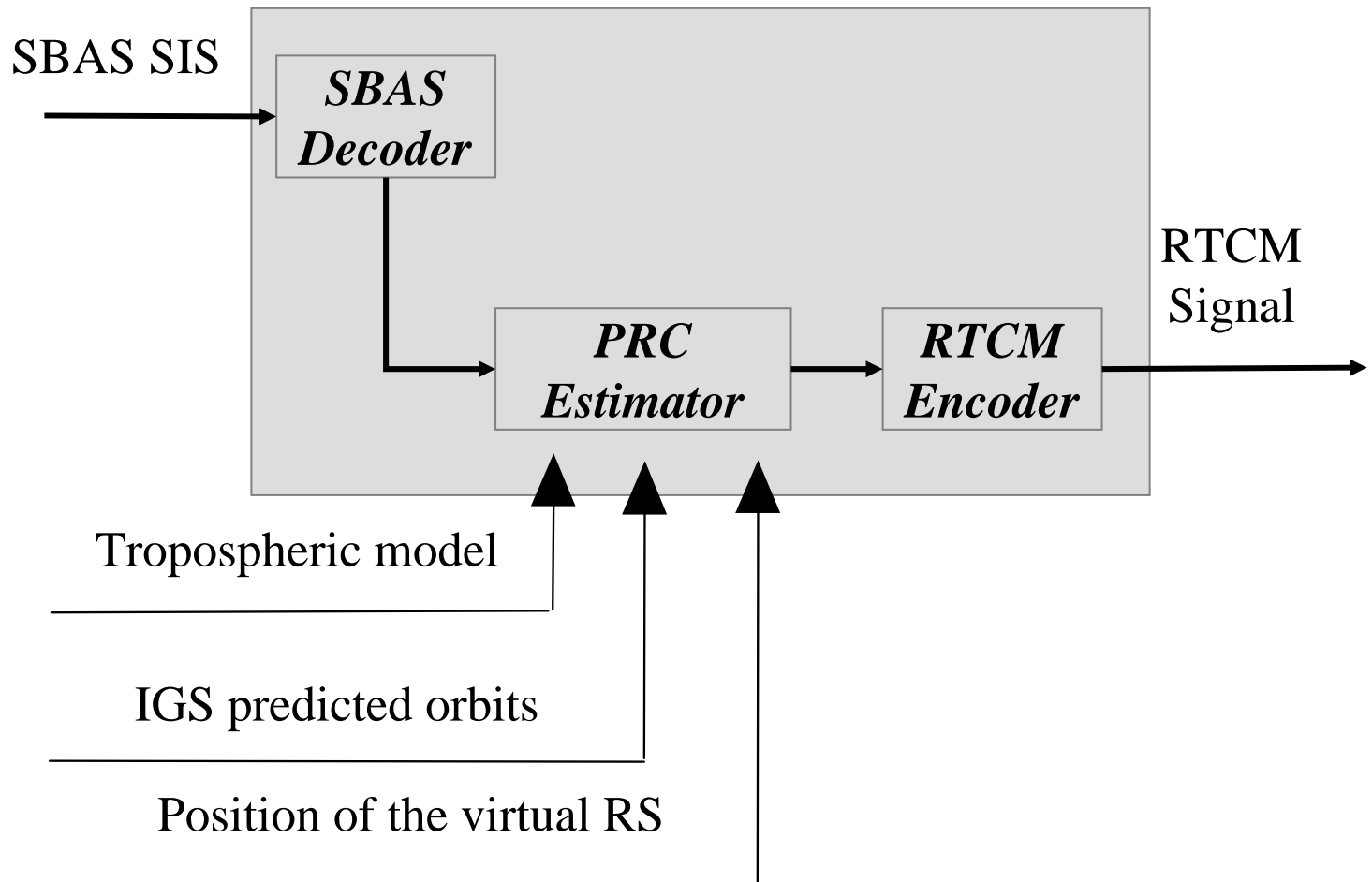




# SBAS/RTCM Converter



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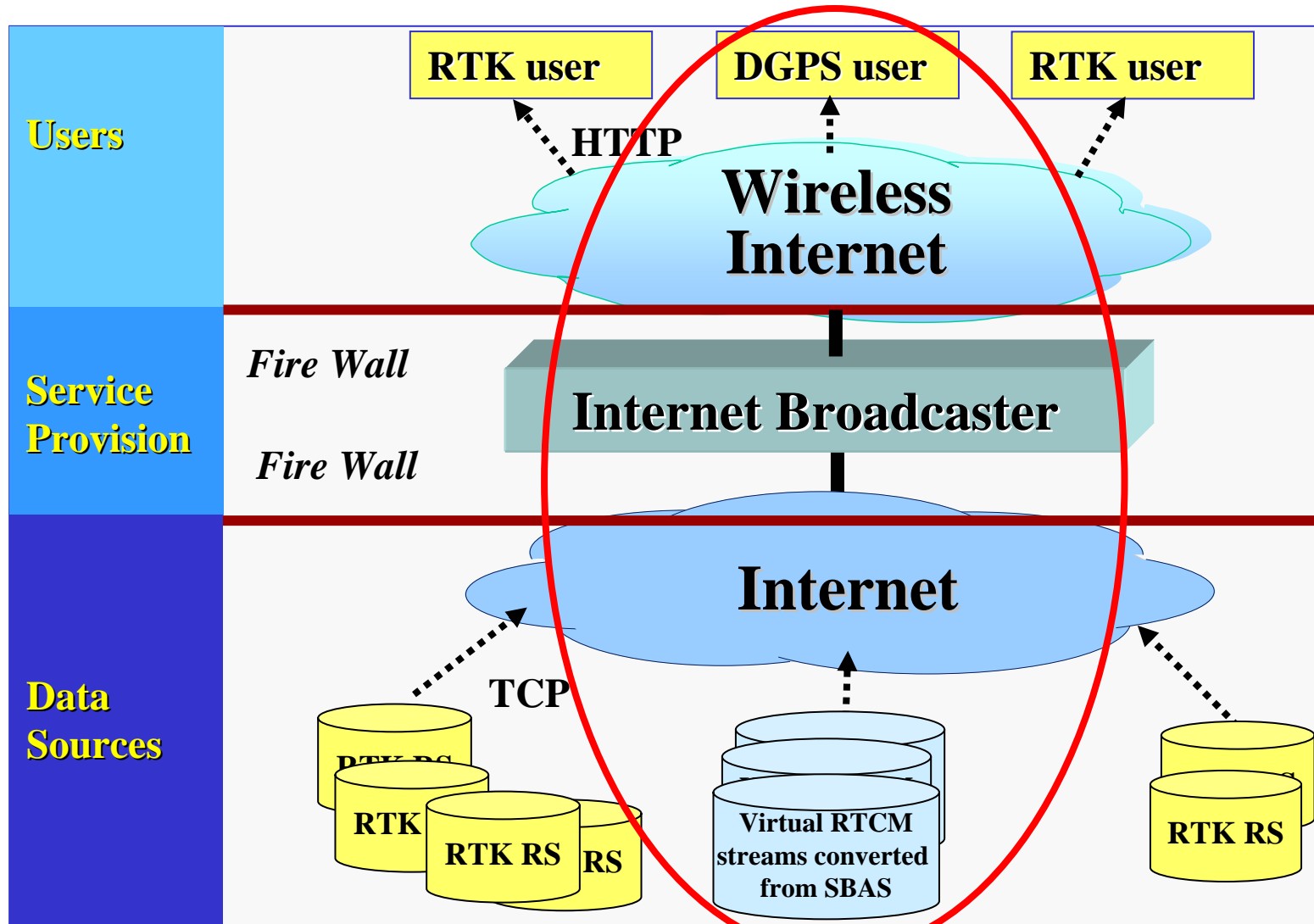




# Internet Broadcaster – the Concept



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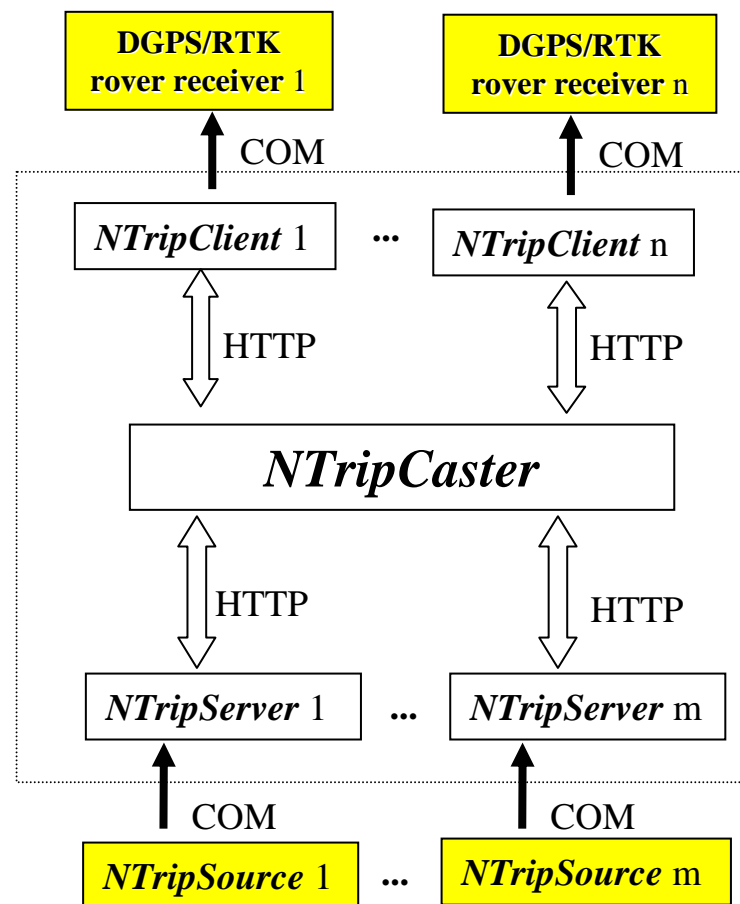




# Internet Broadcaster

## The NTRIP Concept

- It is based on the Internet radio technology (IceCast).
- It consists of three components: *NtripSource*, *NtripCaster* and *NtripClient*
- It supports the multiple-to-multiple solutions for network-based RTK solutions.
- It can be used for the transmission of other data streams *e.g* IGS predicted orbits.
- The NTRIP protocol is developed by the German Federal Agency of Cartography and Geodesy

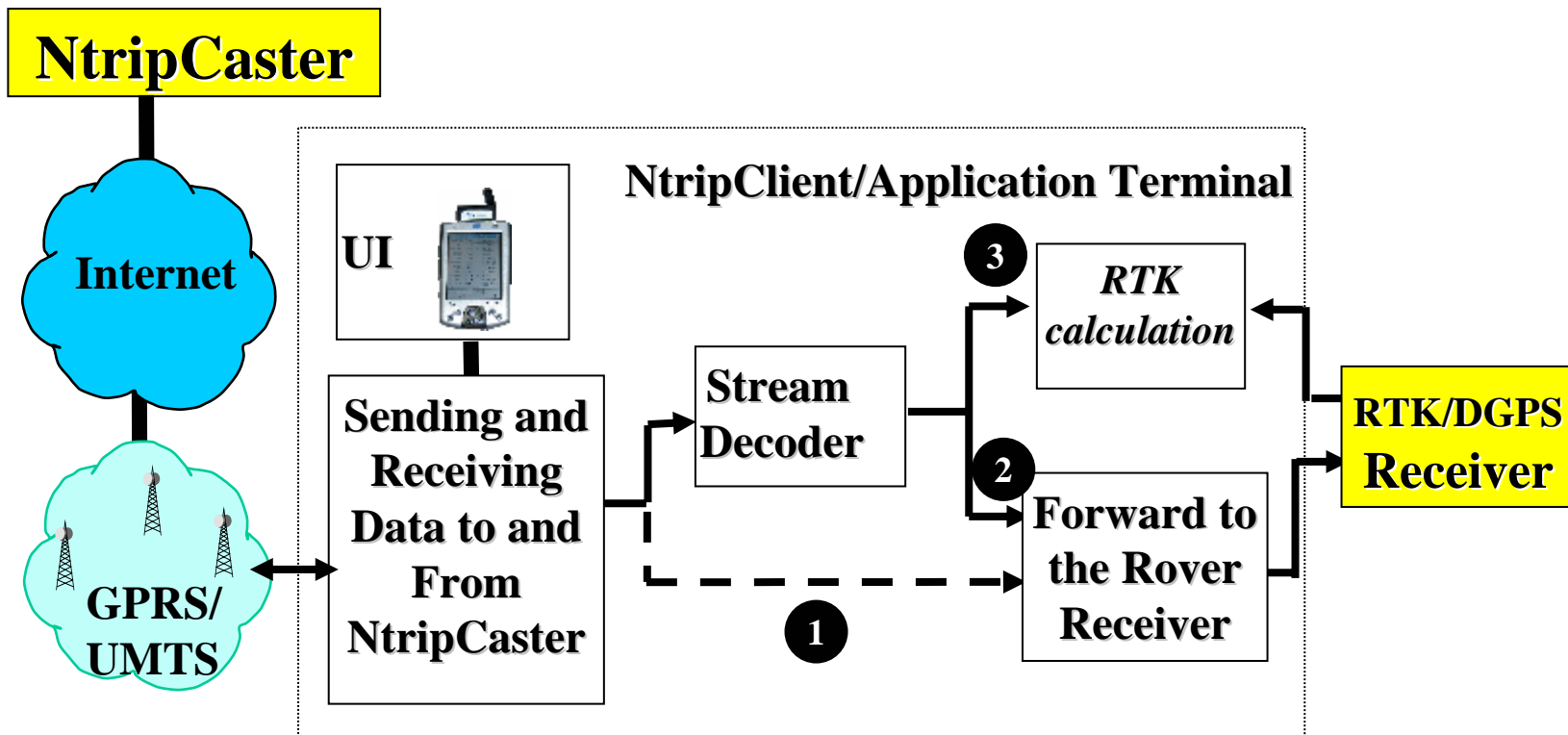


NTRIP = Network Transport of RTCM via Internet Protocol.



# Development of the NtripClient

## Three Development Options

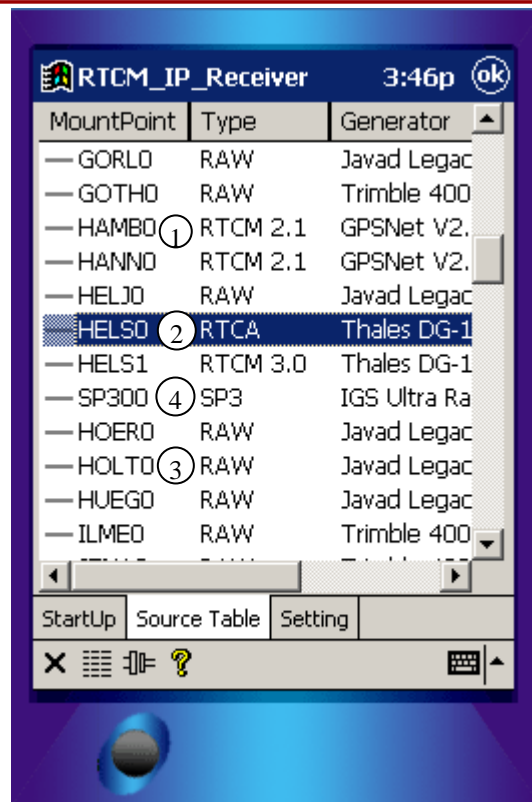




# The NtripClient Developed by FGI



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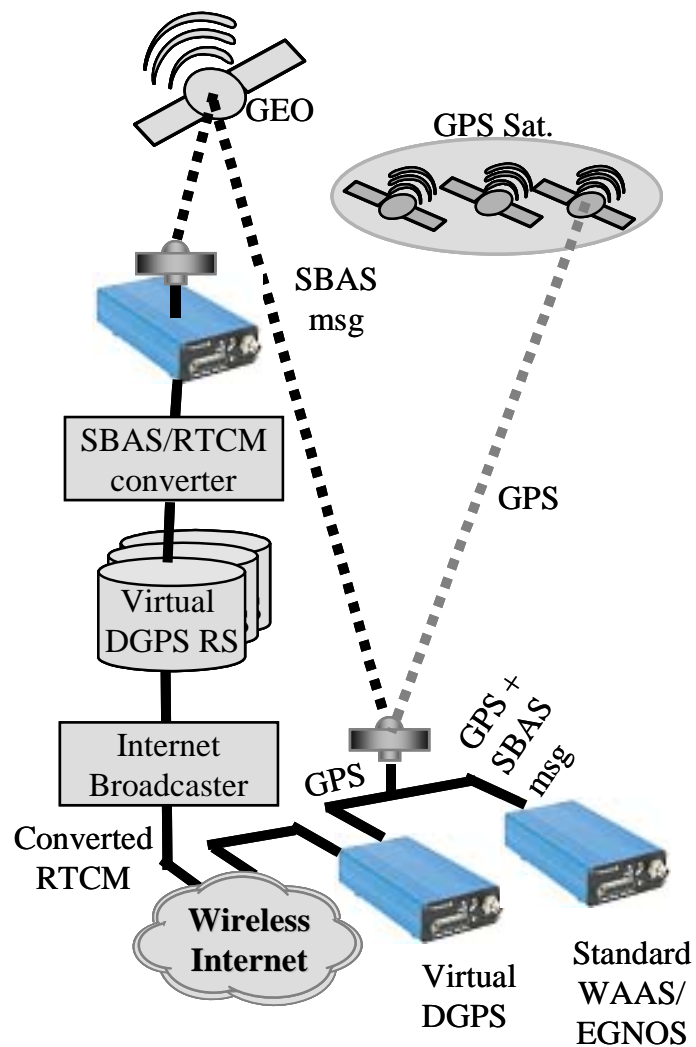


Screen shot of the NtripClient showing different kinds of active data streams including 1)RTCM data streams, 2) RTCA data streams, 3)raw data and 4)a SP3 IGS ultra-rapid orbits.



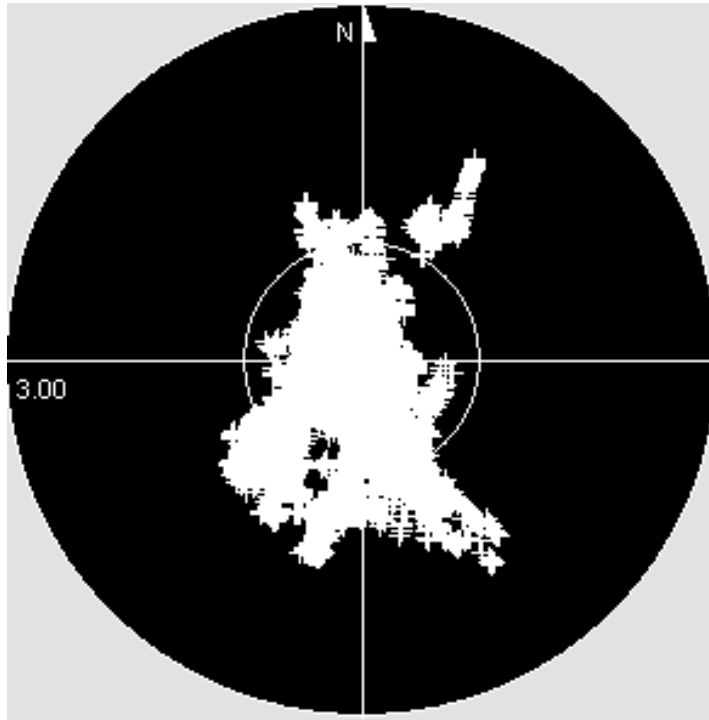


# Test Configuration

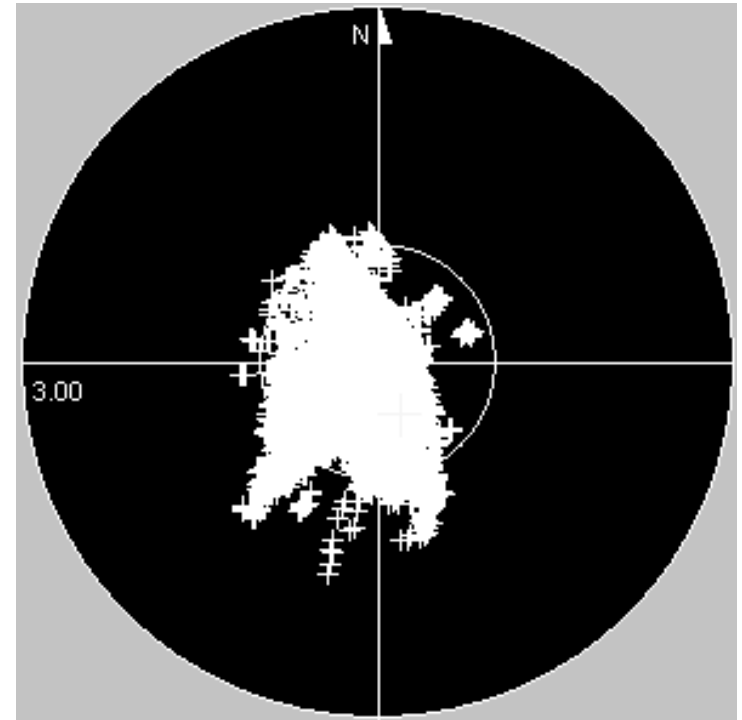




# SBAS vs. Virtual DGPS



**SBAS**



**Virtual DGPS**

**Inner ring = 1m**

**Outer ring = 3m**



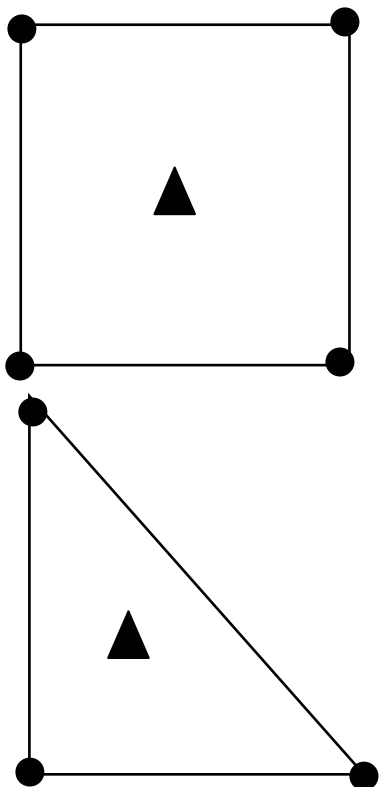
# Ionospheric Vertical Delay Interpolation Improvement



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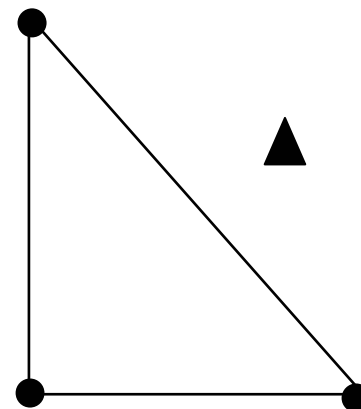
## SBAS Algorithm



● = IGP  
▲ = Pierce Point

## Virtual DGPS

SBAS +



$$v_p = \sum_{i=1}^n w_i \cdot v_i$$

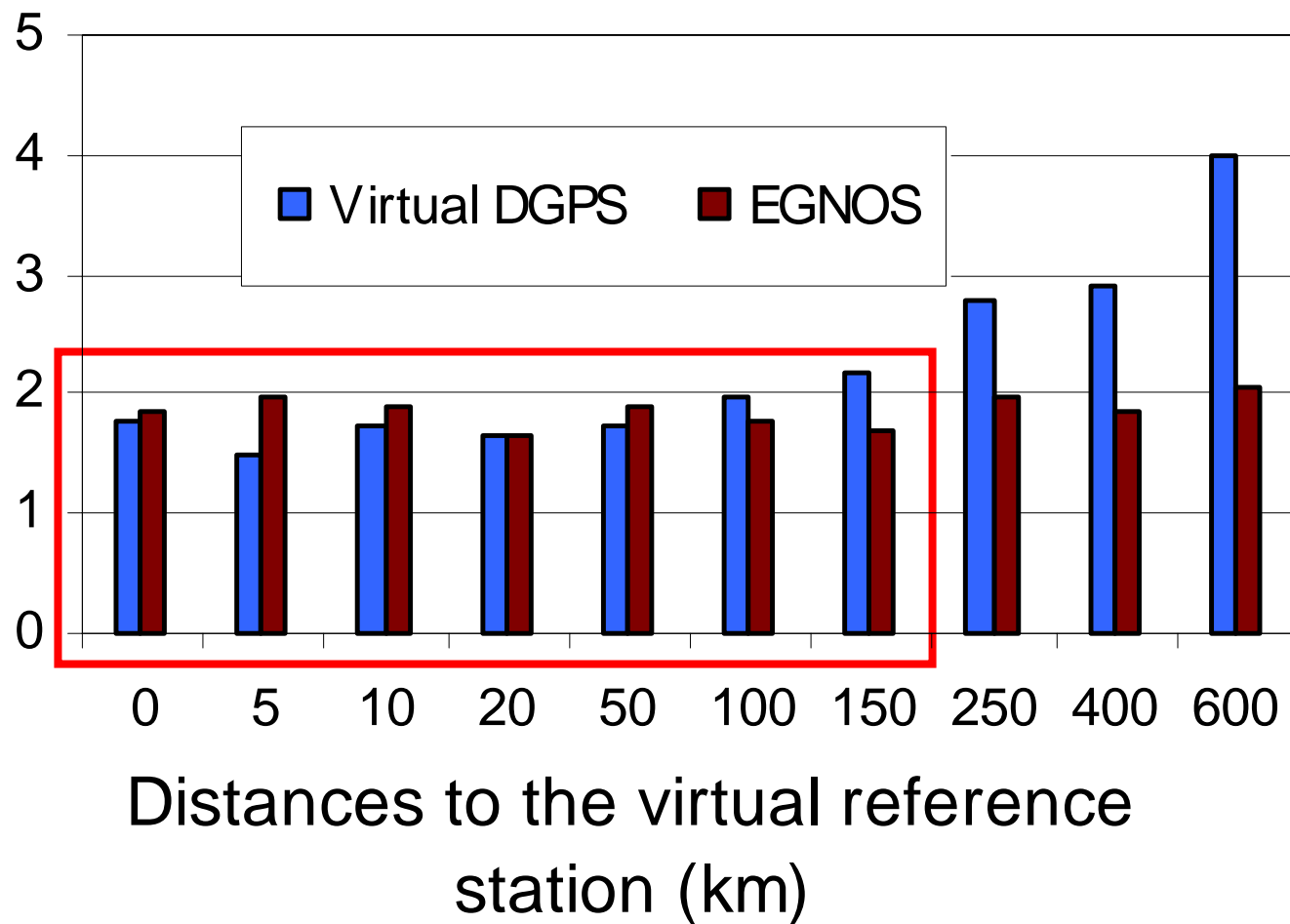
$$\text{with } w_i = \frac{1/s_i^2}{\sum_{j=1}^n 1/s_j^2} \quad n = 1 \wedge 3$$



# Accuracy Degradation at Different Distances

Horizontal errors at 95%

(m)

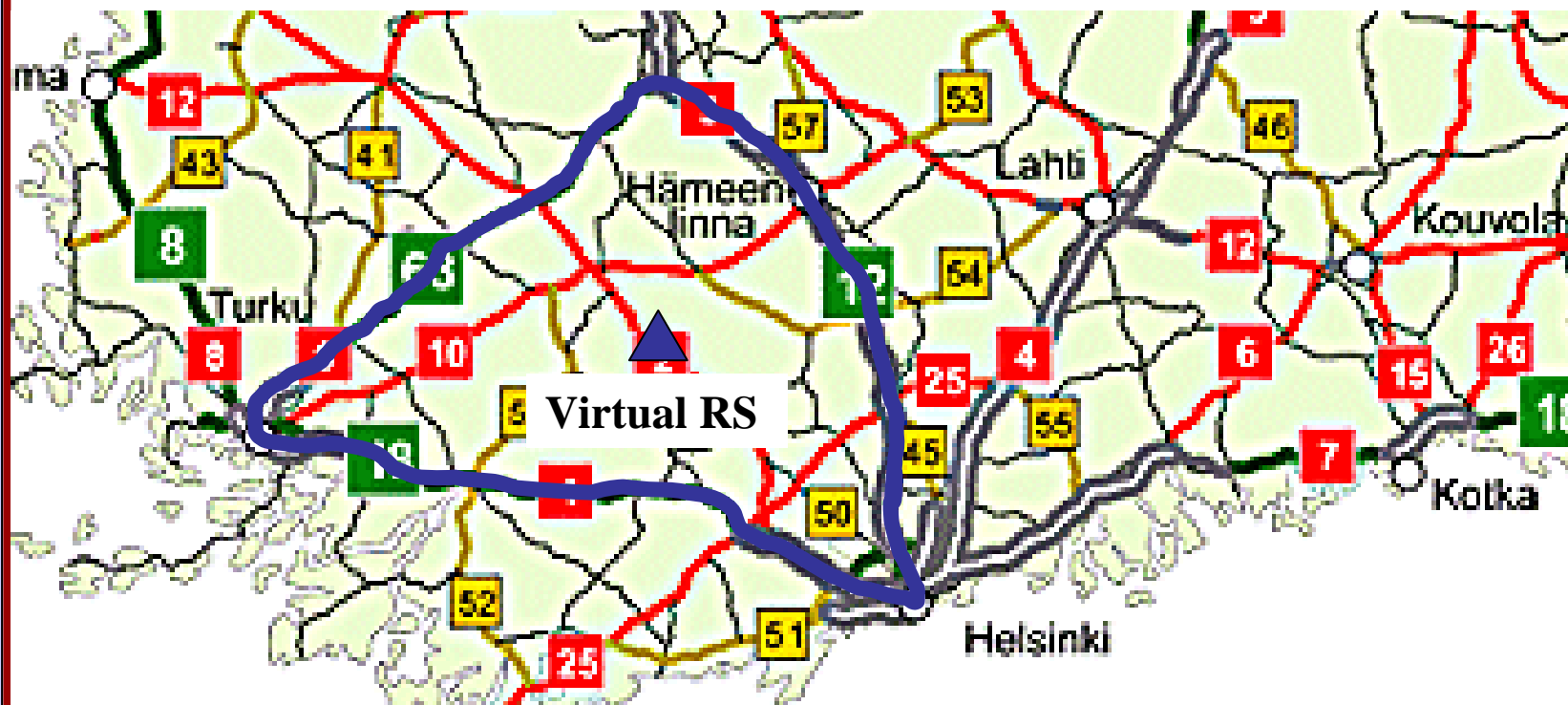




# Availability Test



A preliminary driving test of 400 kilometers in southern Finland showed that the availability of the virtual DGPS solutions was 98.6% along the driving route.





# Benifits of Virtual DGPS



- **Provide similar positioning accuracy as DGPS.**
- **Overcome the limitation of low elevation angles to the GEO satellites and increase the SBAS positioning availability at high latitudes and city canyons.**
- **Made it possible to access the SBAS service via a legacy DGPS receiver.**
- **No initiation process is needed. The end users can access to the SBAS service immediately when they made a connection to the Internet broadcaster.**



## Benifits of Virtual DGPS cont'd



- **Virtual DGPS reference stations can be created anytime anywhere within the SBAS service area.**
- **No investments and maintenance work for a DGPS network are needed as it is a virtual solution.**



# Conclusions



- The virtual DGPS solution provides a positioning accuracy of 1-2 meters, which is similar to that of the standard WAAS/EGNOS solution.
- The accuracy is not degraded as long as the rover receiver is within the radius of 150 kilometers from the virtual reference station.
- A preliminary driving test of 400 kilometers in southern Finland showed that the availability of the virtual DGPS solutions was 98.6% along the driving route.



# Future Works

- FGI is now updating the data communication system of the permanent GPS network, it is expected that the real-time data will be available in 2005.
- The concept can be extended by integrating the local permanent GPS network to EGNOS system to improve the positioning accuracy.

